Centre for the Clinical Application of Particles

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Nuclear medicine

Week 2; Lecture 4; Section 3: SPECT: attenuation correction

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Section 3

Attenuation correction

Attenuation correction strategies

1. Exploit ACF in "Chang's multiplicative method"
2. Generate a transmission map using "attenuation scans"
3. Use mean patient shape
    - Disadvantage "there is no mean (or average) patient"
4. Exploit CT image:
    - X-ray image processed to give transmission map that can be used to calculate ACF as a function of position

Will consider 1 and 2 below

Chang's multiplicative method

Steps:

1. Reconstruct image without any attenuation correction
2. Use reconstructed image to identify contour of patient
3. Assume uniform linear attenuation coefficient, μ, and calculate ACF pixel by pixel
4. ...

Calculation of ACF pixel by pixel

For pixel at position x, y, a distance d_i from the surface in the direction of the camera, the pixel's attenuation factor, η_i, is given by:

$$\eta_i = \exp(-\mu d_i)$$

For a pixel at x, y, can now sum attenuation over all pixels between x, y and the surface to obtain the total attenuation factor for the path:

$$\eta = \frac{1}{N} \sum_{1}^{N} \exp(-\mu d_i)$$

As before, N is the number of projections. The attenuation correction coefficient, now a function of x and y is given by:

$$\mathrm{ACF}(x, y) = \frac{1}{\frac{1}{N} \sum_1^N \exp(-\mu d_i)}$$

Chang's multiplicative method

Steps:

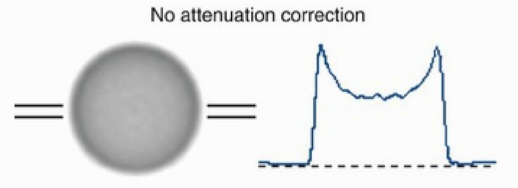
1. Reconstruct image without any attenuation correction
2. Use reconstructed image to identify contour of patient
3. Assume uniform linear attenuation coefficient, μ, calculate ACF(x, y)
4. Apply ACF pixel by pixel:

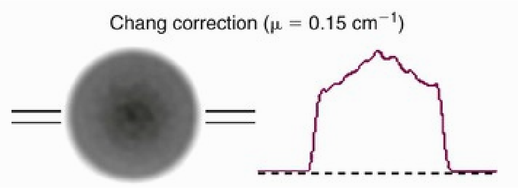
$$f(x,y) = f'(x,y) \times \mathrm{ACF}(x,y)$$

where $f'(x, y)$ is the uncorrected response reconstructed in the pixel at x, y, and $f(x, y)$ is the corrected response.

Example

20 cm diameter cylinder with uniform concentration of ^{99m}Tc.

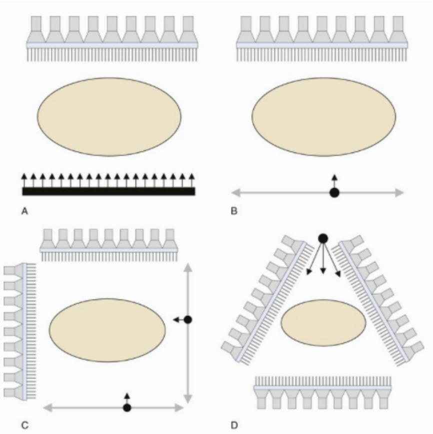




Apparent "over correction" attributed to scattered events.

In this example Chang's method has been applied, followed by a further correction by "forward projecting". The corrected image is projected to the gamma camera. The predicted response of the camera is then compared to the measured response and a further correction is made based on the difference of the forward projection and the measurement.

Transmission scans



A: Flood source
B: Single source
C: 2 orthogonal sources
D: Stationary line source

Reference scan: I_{ref}; transmission scan: I_{trans}
For a particular projection element:

$$I_{\mathrm{trans}} = I_{\mathrm{ref}} \exp(-\mu d)$$

Taking the logarithm of the ratio:

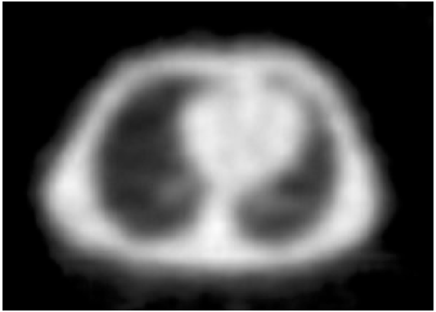
$$\ln\left(\frac{I_{\mathrm{ref}}}{I_{\mathrm{trans}}}\right) = \mu d$$

Back-projection technique yields

$$\mu d = \sum_i \mu_i d_i$$

where the i^{th} pixel is of size d_i and is characterised by μ_i

Transmission scan: example



Transmission map of thorax using moving line source.

Radionuclides for transmission scans:

- ^{99m}Tc ($E_\gamma = 140\,\mathrm{keV}$)
- ^{153}Gd ($E_\gamma = 97\,\mathrm{keV}$ and $103\,\mathrm{keV}$)
- ^{123}Te ($E_\gamma = 159\,\mathrm{keV}$)

Long half-life convenient as then source does not need to be replaced frequently

Summary of section 3

Correction for attenuation an important step in SPECT image-reconstruction process

A variety of procedures are used in practice; Chang's multiplicative method and the transmission-scan method were summarised